NEW SPECIES OF *TILAPIA* (PISCES, CICHLIDAE) FROM LAKE JIPE AND THE PANGANI RIVER, EAST AFRICA

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NEW SPECIES OF *TILAPIA* (PISCES, CICHLIDAE) FROM LAKE JIPE AND THE PANGANI RIVER, EAST AFRICA

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CONTENTS

SYNOPSIS

Three new species and one new subspecies of *Tilapia* are described from the Pangani River system. Field and pond observations are given, and also observations on the growth of *T. esculenta* Graham and *T. variabilis* Boulenger, collected as fry from Lake Victoria and reared in ponds.

INTRODUCTION

In recent years recognition of the need for more protein in the diet of Africans has led to investigations of the growth of African fish in ponds. Certain species of Cichlid fishes of the genus *Tilapia* have proved very amenable to pond culture. This paper is concerned with an investigation, made in January, 1951, of the Tilapia species of the Pangani River system, certain of which were already being grown in fish ponds.

The Pangani River flows through Tanganyika Territory in a south-easterly direction from Lake Jipe, which lies on the Kenya border just south-east of Kilimanjaro, to the Indian Ocean (Text-fig. 1). Samples of Tilapia were collected from Lake Jipe, from ponds at Taveta near Lake Jipe, and from the Tanganyika Government's experimental fish farm at Korogwe. The Taveta ponds were stocked with fry from Lake Jipe. The Korogwe ponds were supplied with water by a channel leading from the Pangani River, and separate ponds were stocked with

Pangani River Tilapia and Lake Jipe Tilapia; Lake Victoria and Belgian Congo species foreign to the Pangani system had been introduced into other ponds at Korogwe.

Lake Jipe is connected with the Ruvu or Pangani River in wet seasons through a series of swamps. In 1951 the lake was about twelve miles long by one and-a-half miles wide, but was said to be silting up and spreading ; it was a shallow lake, only a few feet deep over much of its area, with large patches of water plants, *Potamogeton* and *Najas* species, rising to the surface, and frequented by numerous water birds.

TEXT-FIG. 1. The Pangani River system, Tanganyika Territory.

The Tilapia collected were examined at the British Museum (Natural History) together with other specimens from Lake Jipe collected previously by Mr. H. Copley, Fish Warden, Kenya, and from the Pangani River collected by Major R. E. Gould, Fisheries Officer i/c Fish Farming in Tanganyika Territory. The following Tilapias considered to be new and described below were found:

T. jipe sp. n. and *T. girigan* sp. n. in Lake Jipe ;
T. pangani sp. n. from the Pangani river at Korogwe ; and
T. mossambica korogwe subsp. n. from Korogwe ponds fed by the Pangani River.

Although, at first, resemblances to T. *mossambica* Peters and *T. nigra* Günther suggested that the Jipe and Pangani forms might find a place with these in one supraspecies, closer examination has emphasized the differences and, except for *T. mossambica korogwe* subsp. n., they are here described as distinct species, with some reservation as to the rank of the allopatric *T. pangani* and *T. girigan* relative to each other. *T. jipe* though superficially like *T. girigan* has very distinctive pharyngeal teeth quite unlike *T. mossambica* and more like *T. galilaea* (Linn.). Further knowledge of the ecology of all these species is required before the interspecific relationships can be understood.

These Tilapia are, however, already being used on fish farms and transported round the countryside. It is therefore very desirable that those responsible for the fish should be able to name them to record movements, quite apart from the desirability of recording as much as possible about natural distribution before species from different river systems are inevitably mixed. For example, further study has shown that fish of supposed "*T. nilotica*" grown in the Tanganyika Government's experimental fish farm at Korogwe really belong to the new species *T. pangani*, and appear to be more nearly related to *T. mossambica* than *T. nilotica ;* this explains the differences in behaviour between these fish and the genuine *T. nilotica* which have been tried in dams in Uganda and the Belgian Congo.

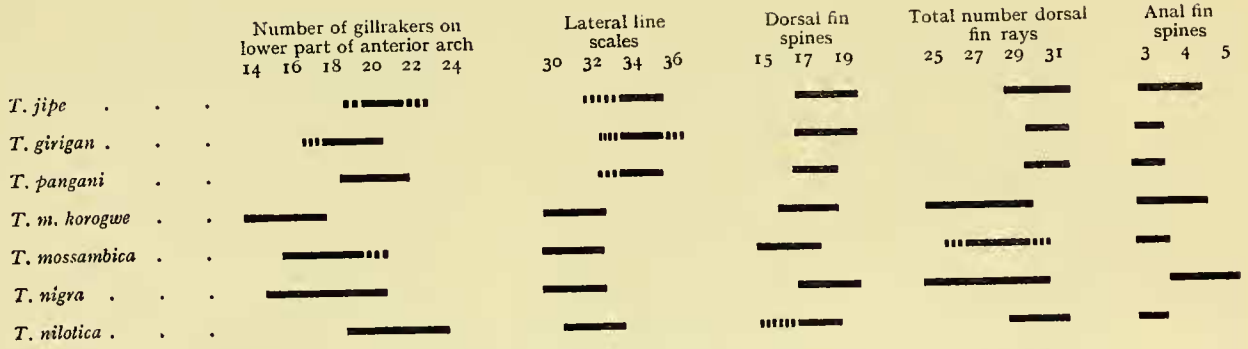
The situation has been further complicated by the introduction of four distinct species foreign to the Pangani system into the Korogwe ponds, *T. esculenta* Graham and *T. variabilis* Blgr. from Lake Victoria, and T. *macrochir* Blgr. and *T. melanopleura* A. Dum., from the Belgian Congo. There are also reports that *T. nigra* Günther was once introduced into streams flowing south from Kilimanjaro, streams which also find their way into the Pangani.

T. mossambica korogwe which was not intentionally stocked in the Korogwe ponds was nevertheless found in them and presumably gained access from the Pangani water supply together with some small *Haplochromis* which also appeared in these ponds. These accidental entries into ponds indicate the difficulty of making really fishproof screens and the need to examine the indigenous Tilapias in these rivers before escapes from ponds, and possibly hybridization with the local species, occur.

A summary of the diagnostic characters of the new forms is given in Table I, and some of their characters are compared with those of *T. mossambica*, *T. nigra* and *T. nilotica* in Text-fig. 2.

TABLE I.—*Diagnostic characters of new species of Tilapia*

	T. jipe sp.n.	*T. girigan* sp.n.	*T. pangani* sp.n.	*T. m. korogwe* sub. sp.n.
No. on which detailed measurements made: Size range—total length cm.	12 of 12–27	19 of 16–31	8 of 22–29	12 of 11–18
Body depth / Standard body length × 100	36·0–40·2	34·2–40·4	31·7–43·5	35·2–40·7
Head length / Standard body length × 100	32·0–36·2	31·6–36·2	30·8–34·3	32·3–35·7
Pectoral fin length / Standard body length × 100	35·2–42·2	30·0–37·4	31·7–39·9	—
Lower jaw / Head length × 100	25·8–33·8	27·8–38·6	32·2–37·1	(34·4 ♀) 36·1–44·5 ♂
Snout / Head length × 100	29·7–39·7	31·9–42·7	34·9–40·4	(34·4 ♀) 36·6–40·0 ♂
Interorbital width / Head length × 100	33·3–40·0	34·4–38·9	34·2–38·2	31·0–36·0
Preorbital depth / Head length × 100	18·7–22·4	18·1–21·7	21·4–23·3	19·05–22·5
Caudal peduncle length / depth	0·80–1·05	0·79–1·00	0·8–1·0	0·69–0·95
Lower pharyngeal bone: length / width	0·95–1·22	0·81–1·00	0·97–1·08	0·91–1·01
Lower pharyngeal bone: toothed area	Heart-shaped	Large triangular	Smaller triangular	—
Lower pharyngeal bone: teeth	Fine, densely crowded	Coarse, well scattered	Intermediate	—
Teeth: number of series: upper jaw	5–8	4–8	5–8	4–5
Teeth: number of series: lower jaw	5–7 (8)	4–6	4–6	4–5
Number of gillrakers on lower part of anterior arch	(19) 20–21 (22)	(17) 18–20	19–21	14–17
Dorsal fin: Number of spines	17–19	17–19	17–18	16–18
Dorsal fin: Number of soft rays	11–13 } 29–31	12–14 } 30–31	12–13 } 30–31	9–11 } 25–29
Anal fin: Number of spines	4 or 3	3	3	3–4
Anal fin: Number of soft rays	10–12 } 14–16	11–13 } 14–16	11–13 } 14–16	8–11 } 11–14
Scales: Lateral line series	(32) 34–35	(33) 34–35 (36)	(33) 34–35	30–32
Scales: Around caudal peduncle	17–20	17–20	18–20	16–17 (18)
Number of series (below eye) on cheek	2	2–3	3	2–3



TEXT FIG. 2.—A comparison of various characters of the newly described species with those of samples of *T. mossambica* Peters (Zambesi and southwards), *T. nigra* Gthr. (R. Athi) and *T. nilotica* L. (R. Nile). Less frequent parts of ranges shown by broken lines.

II. SYSTEMATIC DIAGNOSES

Tilapia jipe sp. n.

(Pl. 13 and 16A)

16 specimens of 5–20 cm. total length from Lake Jipe.

54 specimens of 7–28 cm. from ponds stocked from Lake Jipe.

Tilapia with body proportions, teeth, fin rays, scales and gill-rakers as in the accompanying table of diagnostic characters (Table I). Lower pharyngeal bone with heart-shaped dentigerous area covered with dense velvet of fine teeth (Pl. 16A). Dorsal profile of head convex in smaller specimens but jaws become elongated in mature males giving a concave upper profile. Fin rays long, pectoral generally reaching origin of anal and posterior tip of dorsal extending halfway along caudal; caudal fin long with very definite vertical black or dark brown stripes.

Non-breeding fish light grey with spotted effect caused by the very distinct black or dark brown centre to each scale along back and sides, belly light grey. Faint indications of 7–9 darker vertical stripes on body of some specimens; dorsal and anal fins grey, spotted anteriorly and striped posteriorly with black; caudal fins with vertical stripes; pectoral fins unpigmented, pelvics becoming dark in larger fish. Breeding fish, particularly males, develop green and purple sheen, bright orange edge to dorsal fin and crimson edge to caudal, bluish-green pelvics and bluish-green edge to anal in some specimens; no genital tassel. Fry up to about 8 cm. long have olive-greenish body with 10–14 thin vertical dark brown stripes stretching from dorsal to ventral surface, caudal and hind end of anal striped as in adults; well marked black "*Tilapia* mark" on a clear background extending from the last dorsal spine to the third or fourth soft ray, and followed by three definite black bars on hind end of dorsal fin.

Among the 70 *T. jipe* preserved, 12 (17%) had three anal spines, 5 (7%) had three plus a partly ossified fourth, 52 (75%) had four and 1 (1%) had five.

The type is a male of 162 + 45 mm. (British Museum (Natural History) register number 1952.2.26.2) and the allotype is a female of 140 + 35 mm. (B.M.(N.H.), 1952.2.26.1), both collected from Lake Jipe in January, 1951.

The striped tail (previously thought to be characteristic of *T. nilotica* in East Africa) and general appearance of *T. jipe* are similar to *T. nilotica* Linn., but in contrast with this species, *T. jipe* generally has 4 anal spines and a shallower body, smaller head, wider interorbital, more rows of teeth in the jaws, and the jaws of mature males become accentuated, a characteristic of the *mossambica* group of *Tilapia* and not shown by *T. nilotica*. The pharyngeal bone of *T. jipe* is quite distinct and characteristic, the dense velvet of fine pharyngeal teeth being most like that of *T. galilaea* (L.); however, *T. jipe* differs from *T. galilaea* in having a shallower body, a longer snout accentuated in mature males, a less deep preorbital bone, more lateral line scales, and usually four anal spines.

T. jipe is easily distinguished from the sympatric *T. girigan* by the striped caudal fin, four anal spines, pectoral fin reaching origin of anal fin, the heart-shaped

dentigerous area and fine teeth on the lower pharyngeal bone, less concave profile, and lighter body colour with very distinct spots.

T. girigan sp.n.

(Pl. 14 and 16B)

22 specimens of 5–31·5 cm. total length from Lake Jipe.

9 specimens of 7–23 cm. total length from ponds stocked from Lake Jipe.

Tilapia with body proportions, teeth, fin rays, scales and gill-rakers as shown in the diagnostic Table I. Lower pharyngeal bone with large triangular toothed area and straight posterior edge; pharyngeal teeth coarse and well scattered on bone (Pl. 16B). Jaws becoming elongated in mature fish, more markedly in the males, giving concave upper profile. Fin rays not very long, pectoral not reaching origin of anal; caudal fin immaculate or uniformly dark, or with spots and blotches, but not striped.

Non-breeding fish dark olive-brown, spotted effect due to black or dark brown centre to all the scales on back and sides extending right down to the grey ventral surface. Indications of about nine vertical black or dark brown stripes on some specimens. Dorsal and anal fins dark grey with posterior ends spotted or blotched with black; pectorals immaculate; pelvics dark grey. Breeding males with red or orange margin to dorsal and caudal fins; no genital tassel. Fry up to about 8 cm. total length olive-brown with 10–14 vertical dark stripes; "*Tilapia* mark" as in *T. jipe* fry, but general body colour darker and caudal and hind end of dorsal immaculate or spotted as in adults, but not striped as in *T. jipe* fry.

The type is a male of 210 + 49 mm. (British Museum (Natural History) register number 1952.2.26.3), and the allotype is a female of 177 + 45 mm. (B.M.(N.H.), 1952.2.26.4), both collected from Lake Jipe in January, 1951.

In general body shape and in the development of the jaws and the concave profile of the mature males *T. girigan* resembles *T. mossambica* Peters. It differs from *T. mossambica*, however, in having a higher number of dorsal and anal fin rays [30–31 dorsal rays instead of (26) 27–29 (30), and 14–16 anal rays instead of 12–15], more scales in the lateral line series (33–36) instead of 30–32 in *T. mossambica*), more gillrakers [(17) 18–20 in contrast to 16–19 (20)], and the outer teeth in the jaws remain bicuspid, whereas they often become unicuspid in mature male *T. mossambica*. Also the lower pharyngeal bone of *T. girigan* has a shorter blade and stouter appearance than in *T. mossambica* (compare Pl. 16. B and E.). The pharyngeal teeth of *T. girigan* are most like *T. nilotica* Linn., (Pl. 16F) but the toothed area is larger in *T. girigan*. *T. girigan* has a higher number of scales in the lateral line series (33–36 instead of 31–33 in *T. nilotica*), and lacks the striped tail of *T. nilotica*. Males of *T. girigan* show lengthening of the jaws and development of a concave profile as in *T. mossambica*, a character not found in *T. nilotica*. *T. girigan* is very like *T. pangani* and may have arisen as a lake form of this species, but in *T. girigan* the lower pharyngeal bone and the toothed area are larger and the teeth considerably coarser, longer, stronger and more scattered on the bone than in *T. pangani* of comparable sizes, and the preorbital bone is not so deep. *T. girigan* from Lake Jipe

were considerably darker in colour than *T. jipe* from the lake, and darker and more spotted than *T. pangani* ; in both *T. girigan* and *T. jipe* specimens from the ponds were lighter in colour and more spotted than those from the lake.

T. pangani sp. n.

(Pl. 15 and 16c).

8 specimens of 22–29 cm. total length.

Tilapia with body proportions, teeth, fin rays, scales and gillrakers as shown in the diagnostic Table I. Lower pharyngeal bone smaller and with smaller toothed area, and with a flatter posterior edge than that of *T. girigan ;* pharyngeal teeth finer, particularly anteriorly, and closer together than in *T. girigan,* but coarser than in *T. jipe* (compare Pl. 16c with A and B). Jaws lengthening in mature males, giving concave upper profile. Dorsal, anal and caudal fin rays as long as in *T. girigan*; pectoral not reaching origin of anal; caudal fin with dark spots or blotches, or slight stripes at base only (not striped as in *T. jipe*).

Non-breeding fish brownish or grey, dark centres to scales on body but general impression not so spotted as in *T. girigan* or *T. jipe*; indications of vertical stripes (about 9) in some specimens; pectoral fins, and in some small ones pelvics, immaculate; pelvics pigmented in larger specimens. Posterior end of dorsal and anal fins spotted or barred with dark brown or dark grey. Breeding fish, particularly males, lose the vertical stripes, develop a purple-green sheen, dark pelvic fins, bright orange margin to dorsal and bright crimson margin to caudal fin ; no genital tassel.

The type is a male of 236 + 74 mm. collected from the Pangani River near Korogwe by Major Gould in 1949 [British Museum (Natural History), register number 1952.2.26.39], and the allotype is a female of 189+46 mm. collected from a Korogwe fishpond, stocked from the Pangani River, in January, 1951 [B.M.(N.H.), 1952.2.26.40].

T. pangani is like *T. mossambica* Peters in general facies and development of the jaws and concave profile of the mature male, but in contrast with *T. mossambica* it has (*a*) a higher number of dorsal fin rays [30–31 ; contrast (26) 27–29 (30)] ; (*b*) a higher number of anal rays (14–16 contrast ; 12–15) ; (*c*) more scales in the lateral line series [(33) 34–35 ; contrast 30–32]. *T. pangani* is distinguishable from *T. girigan* by the more *mossambica*-like pharyngeal teeth on the smaller lower pharyngeal bone, and the deeper preorbital bone.

It is interesting to note here a report from Major Gould that whereas *T. mossambica* from the lower Pangani can be transferred to, and live in, seawater lagoons, *T. pangani* does not survive this transfer.

T. mossambica korogwe subsp. n.

(Pl. 16D).

12 specimens of 11–18 cm. total length.

Tilapia with body proportions, teeth, fin rays, scales and gillrakers as shown in the diagnostic Table I. Lower pharyngeal bone with short blade, toothed area very

like *T. mossambica* but teeth slightly coarser. Mouth very large, wide and thick-lipped with wide tooth bands; jaw teeth small, poorly developed, weakly cuspidate and well embedded, teeth of both outer and inner series tending to be unicuspid at the sides of the mouth in almost all specimens (including the female). Eyes much more dorso-lateral than in other *Tilapia*. Pectoral fins short, not reaching anus.

Body dark silvery grey, longitudinal black bands along lower lateral line, with indications of about 7 vertical black bars across this line. Line of 4 or 5 black spots above dorsal lateral line and black spot on dorsal side of caudal peduncle. "*Tilapia* mark" an oval black spot near hind end of dorsal fin. Tail immaculate dark grey. Long dorsal and anal fins; anal and pelvics and ventral surface of body dark grey. Mature males with white or grey tip to caudal fin and small (2 mm.) white genital papilla. Female (one specimen only) lighter grey with more definite vertical black stripes (8) and black spot on dorsal side of caudal peduncle; mouth not so large as in males.

This *Tilapia* appeared in several of the fishponds at the Tanganyika Government experimental fish farm at Korogwe. Its origin is uncertain but it seems most probable that it gained access to the ponds with the water supply, which is a cut flowing from, and returning to, the Pangani River. Only one female, caught together with the males and believed to be the female of this subspecies, was found, so the description of the female given above must be considered with reservation.

The type is a male of 140 + 43 mm. collected by Gould in 1951, from one of the Korogwe ponds [British Museum (Natural History) register number 1952.2.26.37]. The one female of 91 + 29 mm. collected in January, 1951, from one of the Korogwe ponds [B.M.(N.H.), 1952.2.26.5] is considered, on present evidence, to be the female of this subspecies and is, therefore, selected as the allotype.

T. mossambica korogwe is very like *T. m. mossambica* in general facies and in the development of the concave upper profile in the males and in the simplification of the jaw teeth, but it has a lower number of gillrakers [14–17 instead of 16–19 (20) in *T. mossambica*], a higher number of dorsal spines (16–18; contrast 15–17 in *T. mossambica*), and four anal spines in some specimens.

In *T. mossambica korogwe* the lower pharyngeal bone has a slightly shorter blade and the pharyngeal teeth are slightly coarser than in *T. mossambica*. The head and mouth are wider in *T. mossambica korogwe* and the simplification of the jaw teeth is even more marked than in *T. mossambica* of comparable sizes and extends to the inner series of teeth. *T. mossambica korogwe* is easily distinguished from *T. jipe*, *T. girigan*, *T. pangani*, *T. nilotica* and *T. esculenta* by the following characters: the very wide head, wide mouth and wide lips, relatively narrow interorbital and the dorso-lateral eyes, small eyes, large preorbital, elongated very concave snout, pelvics far forward and pelvic-anus distance long.

OTHER *TILAPIA* FROM THE PANGANI RIVER

The British Museum collection contains three other specimens of *Tilapia* from the Pangani River and certain fry collected from the Korogwe fish ponds which do not seem to belong to *T. pangani*, *T. mossambica korogwe* or any of the *Tilapia* species

stocked in the ponds. Two of these specimens were collected by Gould in 1949 from the Pangani River together with *T. pangani*; the male was much darker than *T. pangani*, less spotted and with indications of 7 vertical dark bars. These two fishes differed from *T. pangani* in having (*a*) 4 anal spines and 10 soft rays, (*b*) 17–18 dorsal spines and 10 soft rays, (*c*) 31 scales in the lateral line series (instead of 33–35), (*d*) 15–16 gillrakers on the lower part of the anterior arch (contrast 19–21 in *T. pangani*). In all these characters they correspond well with *T. nigra* Gthr. There are reports that *T. nigra* were once introduced into the streams flowing from the south side of Kilimanjaro; such streams drain into the Pangani, so these fishes may not be indigenous. Two small *Tilapia* (7–8 cm.) found in the Korogwe ponds stocked with *Tilapia* from the Taveta ponds also appear to be *T. nigra*, and may have entered this pond with the water supply from the Pangani.

The British Museum collection also contains a 17 cm. *Tilapia* with three anal spines, 33 scales in the lateral line series and 20 gill rakers, collected from the Pangani by Playfair in 1865, and identified as *Chromis niloticus*[1] (= *T. nilotica*). This fish does not appear to belong to any of the other species described from the Pangani system. *Chromis niloticus* (Hasselquist) collected from the Ruvu (Pangani) at Korogwe are also described by Pfeffer (1896), but the number of specimens seen is not stated. Boulenger (1915) assigns the *C. niloticus* described by Pfeffer to *Tilapia natalensis* (Peters) and *T. nilotica* L. The illustration given by Pfeffer shows that in general facies his *C. niloticus* differs considerably from *T. nilotica* from the type locality, although it agrees with *T. nilotica* in many characters such as the numbers of lateral line scales and gillrakers. No other specimens like Playfair's fish have been found in recent collections; until further material is forthcoming it is impossible to say how this and Pfeffer's fishes relate to the other Tilapias.

III. FIELD AND POND OBSERVATION

A. *T. girigan* and *T. jipe* in Lake Jipe and ponds.

Prior to these investigations it was presumed that the *Tilapia* population in Lake Jipe consisted of one or possibly two new species related to *T. mossambica*. No specific name had yet been given to these fish which were merely referred to as Lake Jipe Tilapia. Field observations did not reveal for certain the existence of two species, but it was noticed that some fishes had four and some had three anal spines, and that the four-spined fishes had a striped caudal fin whereas in the three-spined the caudal fin was striped, spotted or immaculate.

Subsequent examination of samples kept for laboratory study showed that all the four-spined Tilapia belonged to the species now called *T. jipe*, whereas the three-spined Tilapia included both *T. jipe* and *T. girigan*, in the proportion 1.12 *T. jipe*: 1.00 *T. girigan*. The proportions of the two species in the preserved samples suggested that most of the *Tilapia* seen from Lake Jipe happened to be *T. girigan*, whereas most of those from the ponds were *T. jipe*. Many more *T. jipe* than *T. girigan* were found among the fry used for stocking the ponds, which helps to explain

[1] Playfair & Günther, 1896, page 111.

the predominance of *T. jipe* in the ponds ; these fry, 2–10 cm. long, were caught by pulling a sack-cloth seine to the shore through a clearing in the reeds bordering Lake Jipe. Whether *T. girigan* fry inhabit a different zone in the lake or would be found in greater numbers at other times of the year is not known. The large *Tilapia* from Lake Jipe, among which *T. girigan* predominated, were caught by beating the water around gillnets set by day among the patches of water weed.[1]

Twenty-two Lake Jipe *Tilapia* were taken from Taveta to Korogwe Ponds, sixteen had four anal spines and were probably *T. jipe,* three had three anal spines and may have included *T. girigan,* and three had a partly ossified fourth spine. Two of these *Tilapia* were presented to the British Museum in December, 1951, and identified as *T. jipe ;* this confirms the presence of this species at Korogwe. The presence of *T. girigan* at Korogwe needs confirmation ; a sample of fry from Korogwe ponds indicates that *T. girigan* were also there, but *T. girigan* fry are difficult to distinguish from *T. pangani* fry which might have found their way into the ponds accidentally with the water supply.

Length frequencies of male and female *T. jipe* and *T. girigan* are given in Text-fig. 3A and B and summarized in Table II.

TABLE II.—*The sex ratio, length range and minimum breeding sizes of* T. girigan *and* T. jipe.

Place	Fishing method	Species	Sex ratio		Body length (cm.)		Minimum breeding size	
			Male	Female	Male	Female	Male	Female
L. Jipe	Gillnet	Mainly *T. girigan*	41	26	16–32	16–32	21	17
Taveta pond	Pond emptied	*T. girigan* and *T. jipe* (3 anal spines)	143	15	14–28	15–22	21	18
		T. jipe (4 anal spines)	216	36	15–25	14–21	21	15
Taveta pond	Angle	Mainly *T. jipe.*	12	4	17–27	15–17	—	—
Korogwe pond	Pond emptied	*T. jipe* and ? *T. girigan*	24	14	23–30	16–23	—	—

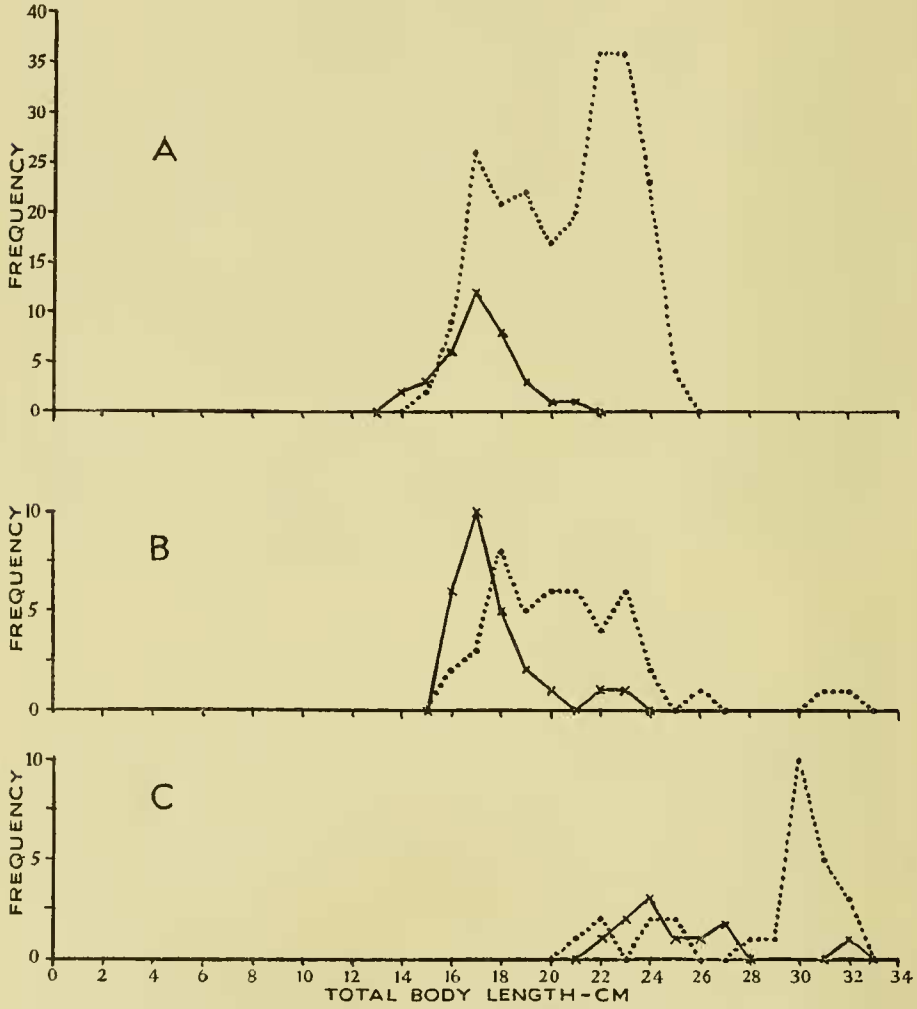
It is immediately clear that in both lake and pond samples, and in those in which *T. girigan* or *T. jipe* predominated :

(*a*) the males were considerably larger than the females ;
(*b*) females started to spawn at a smaller size than the males ;
(*c*) the sex ratio was very unequal, males being more numerous than females ;
(*d*) the pond reared fish were of comparable lengths and minimum breeding sizes with the fish from the lake.

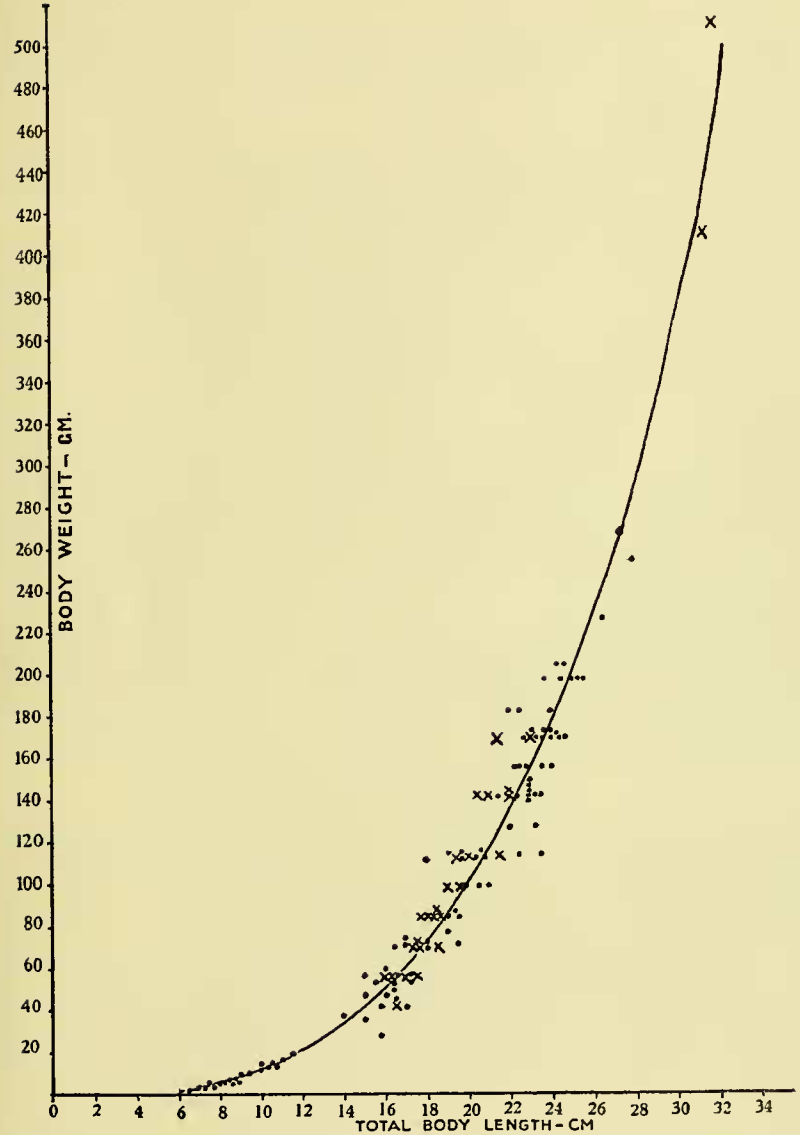
The length/weight relations of *T. girigan* and *T. jipe* are indicated in Text-fig. 4. The pond-reared fish were in very poor condition, i.e. showed a low weight for length, compared with the *Tilapia* from Lake Jipe. This was evidently the result of lack of food in the ponds.

[1] *Petersius tangensis* Lonnberg, previously recorded from Tanga, and *Barbus paludinosus* Peters, a species widely distributed in East Africa, were also caught in Lake Jipe. These species grow only to about 10 cm. long. A few *Clarias mossambicus* Peters, another species widely distributed in East Africa, were found when the Taveta pond was emptied.

The Taveta pond which was emptied on 16th January, 1951, was said to have been stocked with 4–8 cm. *Tilapia* from Lake Jipe about fifteen months previously. After fifteen months in the pond the *T. jipe* (i.e. those *Tilapia* with four anal spines) males were 15–25 cm. long (about 40–200 gm.) with pronounced modes at 17 cm.



TEXT-FIG. 3. Length frequencies of Lake Jipe and Pangani River *Tilapia* reared in fish-ponds. Males ....., females ————. A. Tilapia with four anal spines, probably all *T. jipe*, examined when a Taveta pond was emptied fifteen months after stocking with 2–10 cm. fish from Lake Jipe. B. Tilapia from Lake Jipe mainly *T. girigan*. C. *T. pangani* from a Korogwe pond.



TEXT-FIG. 4. The length/weight relationship of Lake Jipe *Tilapia*. Data from 27 *Tilapia* from Lake Jipe, mainly *T. girigan*, marked thus × ; all other *Tilapia* from Taveta fishponds and mainly *T. jipe*. (Curve fitted by eye.)

and 22–23 cm., and females were 14–21 cm. (about 30–120 gm.), with a pronounced mode at 17 cm. (Text. fig. 3A). Among the three-anal-spined *Tilapia* (T. *girigan* and *T. jipe*) from the pond the males were 14–28 cm. (30–206 gm.) and females 15–22 cm. (40–140 gm.). Both species had been breeding for some time as the pond contained numerous fry of 6–11 cm.; *T. jipe* fry were the more numerous but fry of both species were found.

Adult *Tilapia* from Taveta ponds were taken to Korogwe in October, 1950, and numerous fry 2–6 cm. long of *T. jipe* and probably also *T. girigan* (see above) were seen when the pond was examined in January, 1951.

Text-fig 3B gives the relative sizes of males and females from catches in Lake Jipe in which *T. girigan* were highly predominant. Both *T. girigan* and *T. jipe* females were breeding at a considerably smaller size than the males. In Lake Jipe *T. girigan* males of 21 cm. (about 140 gm.) and females of 17 cm. (about 60 gm.) were spawning. In the Taveta pond *T. jipe* males were also spawning at 21 cm. (though only about 120 gm. weight), and females of 15–21 cm. (about 28–120 gm.) were ripe. The ovaries of ripe *T. jipe* from the Taveta pond were dark yellow and counts of ripe eggs in the ovaries showed that 200–250 eggs are laid at a time by these small females. *T. jipe* females are oral incubators; females were found with up to 167 eggs in the mouth and others were seen carrying yolked young. In the Taveta pond females as small as 15 cm. long were found brooding eggs. *T. girigan* is also a mouth brooder; up to 60 eggs were found in the mouth of one female. No males of either species were found carrying eggs.

Although no *Tilapia* nests were seen on the bottom of the Taveta pond, some were examined when the Korogwe pond stocked with Lake Jipe *Tilapia* was emptied. These nests (Pl. 17A) were identical in appearance with those made by *T. pangani*. Each nest consisted of two or three series of small pits around a larger central pit, the whole excavation being about two and-a-quarter feet across. It is not yet known for certain which of the two Lake Jipe Tilapias made this nest, but they were probably made by *T. jipe*, and similar nests have been reported from the Taveta ponds in which *T. jipe* predominated. It was surprising to find similar nests made by *T. jipe* (or *T. girigan*) and *T. pangani* and this observation needs confirmation by a more reliable correlation between nest and species responsible for it. For comparison with these nests Plate 17B shows the simple circular hollows, about twelve inches in diameter, made by *T. esculenta* in one of the Korogwe ponds.

The scales of 25 pond-living *Tilapia* showed that in most (88%) cases the immature fishes have uniform scales whereas the scales of the mature show "checks"; these checks were near the edge of the scales in fishes which had recently spawned. In males the checks appear as a band of circuli spaced more closely than on the rest of the scale. In the females the checks are clear spaces, as though several circuli had been eaten away; it is thought that these represented spawning marks. Several of the females grown from fry in the Taveta pond showed three (and one showed four) such "spawning marks" after about fifteen months in the pond. Such checks should prove useful for comparison of the growth of mature *Tilapia* under different conditions.

The two species of Tilapia had not been distinguished when the samples of stomachs

and intestines were collected from *Tilapia* from the Lake, and data from pond fish were influenced by the food available in the pond. Hence the data are not sufficient to show any difference in feeding habits between the two species. Among the preserved sample of *Tilapia* from Lake Jipe, however, ten *T. girigan* contained food, mostly chewed water weed (*Najas* sp.) with a good supply of epiphytic diatoms and other algae, or vegetable debris and algae from the bottom of the lake. The two *T. jipe* preserved from Lake Jipe did not provide any information on the food of this species under natural conditions ; the dense felt of pharyngeal teeth in this species suggests that these fish feed on very small particles, probably algae, possibly phytoplankton. The guts of ten other *Tilapia* from the lake, probably mostly *T. girigan*, contained the same kinds of vegetable matter as the preserved *T. girigan*. In several cases both plant material and bottom debris occurred in different parts of the alimentary tract of individual fish showing that the individual *Tilapia* varies its feeding habit. The pond fish, both species, had been eating bottom debris or mud with very little organic matter. The size of the particles of bottom debris, etc., in the guts of the pond fish did, however, reflect the degree of coarseness of the pharyngeal teeth, the stomach and intestines of *T. girigan* containing larger particles than did those of *T. jipe*, which has much more dense pharyngeal teeth. As the rectum of Lake Jipe *Tilapia* in many cases contained food which was originally very different from that in the stomach it was difficult to be certain how much of the food eaten was used. It was clear, however, that diatoms were digested, that some plant cell contents were extracted, but that much of the plant material eaten and the bluegreen and green algae (including filamentous greens) pass through these *Tilapia* unused.

Most of the *Tilapia* examined from Lake Jipe carried large numbers of nematodes in the pericardium. Some of the pond fish were similarly parasitised ; the apparently more numerous parasites in the lake fish may be related to the more numerous aquatic birds on the lake.

B. *T. pangani*

A sample of 39 *Tilapia* originally caught in traps in the Pangani River and living in one of the Korogwe breeding ponds was examined. The 27 males ranged from 21 to 32 cm. long with a pronounced mode at 30 cm. and the females from 22 to 32 cm. with a mode at 24 cm. (Text-fig. 3C). The size of these fish and the sex ratio in this sample may perhaps have been due to selective action by the trap in the river. This pond also contained numerous fry of 1–10 cm. long and the nest identical in appearance with that shown in Plate 17A. These adults had been in the ponds for two years ; it was said that they had not grown much during this time and that batches of young were found every six weeks throughout the year. The pond contained little food for these fish.

C. *T. mossambica korogwe*

Nothing is known of the habits of this small *Tilapia* found together with *T. variabilis* and *T. pangani* in various ponds at Korogwe. It seems most probable that it gained access to the ponds with the water supply from the Pangani River. The

T. m. korogwe were very docile, lying quietly on the bottom of the pond when the pond was emptied and in contrast with *T. variabilis* which leapt about the mud very actively in similar circumstances. Males as small as 16 cm. long were ripe though they did not have a marked breeding dress. Intestines contained insect remains and algal filaments. In spite of little food in the ponds these fish were in fairly good condition which suggests that the breeding size of this species in the natural environment may be similar to that in these ponds. The largest specimen seen was 18 cm. long. The only female seen (to eight males) was 12 cm. long and the ovary was already ripening.

D. Lake Chala Tilapia, *T. hunteri* Günther

Lake Chala, an isolated lake on the foothills of Kilimanjaro in the Pangani drainage area, was visited on 15th January, 1951. The *Tilapia* from this lake, *T. hunteri* Günther, are endemic and of particular interest since there is no apparent inflow or outflow to this deep, clear lake. Only immature *Tilapia* were caught. *T. hunteri* has been described as having four anal spines; of the twenty-one caught, however, only seven had four anal spines, the other fourteen had three. The shores of Lake Chala are rocky and shelve steeply into deep water. The immature *Tilapia* were in small shoals, each shoal of similar sized *Tilapia*, feeding on algae and debris off the bottom between the rocks near the shore ; large numbers of crabs [*Potamon* (*Potamonautes*) *platycentron* (Hilgendorf)] were also living among these rocks. *T. hunteri* may be distinguished from *T. pangani*, *T. girigan*, and *T. jipe* by the long shallow body (body depth 36 %of standard length in 21 cm. fish), long narrow caudal peduncle (length/depth 1·35 in 21 cm. fish) and a small narrow toothed area on the pharyngeal bone. *T. hunteri* appears to be endemic to Lake Chala ; its relationship with other *Tilapia* is not yet known.

IV. LAKE VICTORIA SPECIES OF TILAPIA GROWN IN PONDS

T. esculenta Graham and *T. variabilis* Boulenger have been introduced into the experimental ponds at Korogwe. These species are endemic to Lakes Victoria and Kyoga and do not occur naturally in the Pangani System, but data concerning their growth in these ponds are given here, as in several respects they behaved rather differently from the Pangani system Tilapia grown in the ponds. The fry (less than 20 mm. long) of both species were taken from the mouths of brooding female fish caught near Mwanza at the south end of Lake Victoria and were introduced into a small pond at Korogwe on 16th June, 1950. These fish were examined on 21st January, 1951, six and three-quarter months later, and the following observations were made.

T. esculenta Graham

There were 9 males and 7 females surviving. The males had grown to 16–17 cm. and were ripe, the females to 17–19 cm. and had spawned (Text-fig. 5A). The bottom of the pond had 46 nests, although only 16 breeding fish were present.

Each " nest " was a simple circular hollow in the bottom mud, about twelve inches across and a few inches deep (Pl. 17B); these nests were in about three feet of water.

Numerous *T. esculenta* fry up to 7 cm. total length were seen. It was said that this pond had been emptied and fry observed early in December, only six months after the original fry were put into the pond.

These *Tilapia* had very little nutritious food. Stomach contents showed that they had been feeding on bottom mud and diatoms. Many of the diatoms in the stomach were already empty or half empty and some diatoms in the rectum still contained some contents, possibly because of the amount of mud passing through the gut at the same time which might impede digestion.

In Lake Victoria male and female *T. esculenta* are generally at least 20–25 cm. long before they start to spawn. These *Tilapia* taken from the mouths of " normal sized " Lake Victoria *Tilapia* were breeding when 16–19 cm. long, and six and three-quarter months old.

T. variabilis Boulenger

There were 12 males and 13 females surviving. The males and females were growing at the same rate, fish of both sexes having grown to 13–19 cm. (with a mode at 16 cm). in six and three-quarter months (Text-fig. 5B). A number of the fish were ripe, but only one nest was seen. This was a simple circular hollow like the *T. esculenta* nests and like many of the *T. variabilis* nests seen in Lake Kyoga in Uganda.

Numerous fry 1–6 cm. long were present. It was said that no fry had been seen when the pond was emptied in December, 1950.

These *T. variabilis* were noticeably more active than the other *Tilapia* species, leaping about in the mud when the pond was emptied.

They had not grown quite so fast as the *T. esculenta*. Males and females showed the same rate of growth which bears out observations on Lake Victoria. Both sexes were breeding at 16 cm. long and when less then seven months old under these conditions, though in Lake Victoria from whence the fry came they would probably not start to breed until about 20 cm. long.

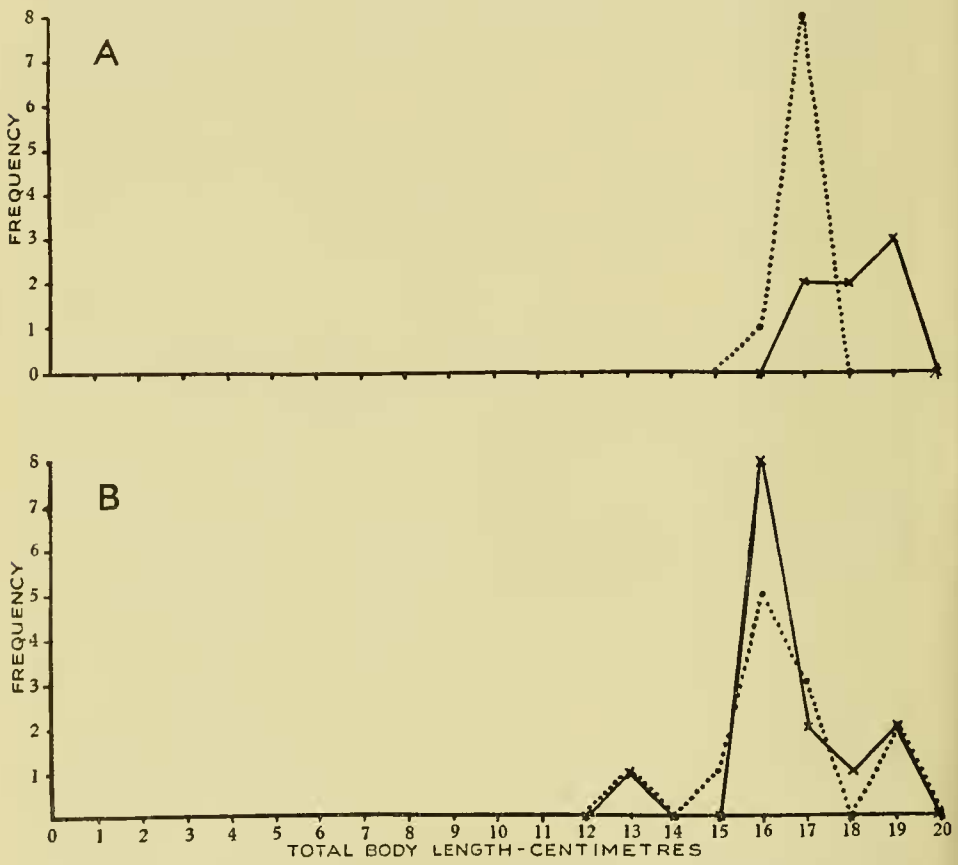
V DISCUSSION

The few odd specimens from the Pangani which do not fit into any of the new species described here suggest that there are further Tilapias in the Pangani system. Further field work is essential for sorting out these species and finding out how the various species keep distinct. Such field work needs to be done immediately as the introduction of species foreign to the Pangani system into ponds, and the probability that some will escape into the river, makes the task of unravelling species increasingly difficult and the results of less value in throwing light on the origin, evolution and distribution of these Tilapias.

It was expected that differences in breeding colours and nests would help to keep the species distinct, and it is surprising to find breeding colours so similar in the two

species of Lake Jipe, and that the nests of these and of *T. pangani* should be alike. Further observations are required in the light of the definitions of the species here presented.

Among the *T. girigan* and *T. jipe* grown in the Taveta ponds the males were considerably larger than the females of the same age. Either the males grow faster



TEXT-FIG. 5. Length frequencies of Lake Victoria Tilapias grown in fishponds, six and three-quarter months after the ponds were stocked with fry less than 20 mm. long. Males ....., Females ———. (A) *T. esculenta*. (B) *T. variabilis*.

than the females or they continue to grow after growth in the females has slowed down. It would be interesting to know how much this is an inherent character of these species and how much it may be influenced by the very unequal sex ratio, the more numerous males having more energy available for growth than the females who may be constantly engaged in reproduction. Among the *T. variabilis*, males and females grew at approximately the same rate, but there were approximately

equal numbers of males and females. Among *T. variabilis* and *T. esculenta* in Lake Victoria males and females are of comparable sizes and appear to grow at the same rate. The males of *T. mossambica* Peters are larger than the associated females, and Baerends and Baerends van Roon (1950) have shown that in this species[1] the size of the male is important in allowing him to establish and keep a spawning territory. Further observational and experimental work is needed to elucidate why sexual dimorphism and size differences exist in some species of *Tilapia* and not in others.

The snout of mature male *T. girigan*, *T. pangani*, and to a lesser extent *T. jipe* becomes elongated and the fish develops a very concave upper profile, as in *T. mossambica* Peters. The few large females also tended to develop the "male" profile, though to a lesser extent. Thus it seems that the elongation of the snout is partly a sexual character and partly a growth character, the snout showing positive allometric growth in relation to the growth of the fish.

This study has shown a variation in the number of anal spines in three species of *Tilapia*, *T. jipe*, *T. m. korogwe* and *T. hunteri* Günther; this character was previously considered to be of considerable stability and specific significance in this genus. Trewavas (1937) described fossil *Tilapia* with four anal spines from Pleistocene deposits at Rawe near Lake Victoria and concluded that they belonged to *T. nigra* Günther. Greenwood (1951*b*) discussed fossil *Tilapia* with four anal spines from Miocene deposits on Rusinga Island, Lake Victoria, and considered these were most closely related to *T. mossambica* Peters, especially specimens from the Tana system (types of *Chromis spilurus* Günther 1894). Summarizing the geological evidence in connection with the distribution of *Haplochromis* species in East Africa, Greenwood (1951*a*) concluded that the eastward flowing rivers probably provided retreats for fish from Lake Karunga during the Miocene drying-up period. Lake Victoria now lies in part of the area formerly covered by Lake Karunga and it seems likely that the *Tilapia* found today in the Pangani system may have had a common origin with the four spined forms now fossilized near and in lake Victoria. Dr. E. Trewavas of the British Museum (Natural History) is at present studying the *Tilapia* of the Tana and other eastward-flowing rivers of East Africa. Her results are awaited with great interest and it is hoped that they will illuminate the relationships and probable lines of evolution of the species described here.

SUMMARY

Three new species and one new subspecies of *Tilapia* are described from the Pangani system, two species from Lake Jipe, *T. jipe* and *T. girigan*, and from the Pangani River a new species, *T. pangani*, and subspecies *T. mossambica korogwe*. *T. girigan* and *T. pangani* appear to be members of the *T. mossambica* complex. A few specimens do not fit into any of these species which suggests that there are further Tilapias in the Pangani. Further field work is necessary to see how the species keep distinct.

T. jipe has a vertically striped caudal fin, previously regarded as a specific "spot test" for *T. nilotica* Linn. in East Africa. The number of anal fin spines, a character

[1] *T. natalensis* = *T. mossambica* Peters (Trewavas 1937).

generally of specific significance among Tilapia, was found to vary in *T. jipe*, *T. m. korogwe* and *T. hunteri* Günther.

Length frequencies of lake and pond fish showed that in both *T. girigan* and *T. jipe*: (*a*) the males were considerably larger than the females; (*b*) the females started to spawn at a smaller size than the males; (*c*) males were much more numerous than females in the breeding population. "Nests" of Lake Jipe *Tilapia* and *T. pangani* are described and compared with the nests of *T. esculenta* Graham in neighbouring ponds.

Observations are given on the growth of *T. esculenta* Graham and *T. variabilis* Boulenger reared in ponds from fry from Lake Victoria. In both these species males and females showed the same rates of growth and started to breed at the same size. Both *T. esculenta* and *T. variabilis* in these ponds were breeding when 16 cm. long and less than seven months old, though in Lake Victoria, from whence the fry came, they would probably not start to breed until about 20 cm. long.

ACKNOWLEDGEMENTS

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PLATE 13

Tilapia jipe, a male of 25 cm. total length from one of the Taveta fishponds.

TILAPIA JIPE

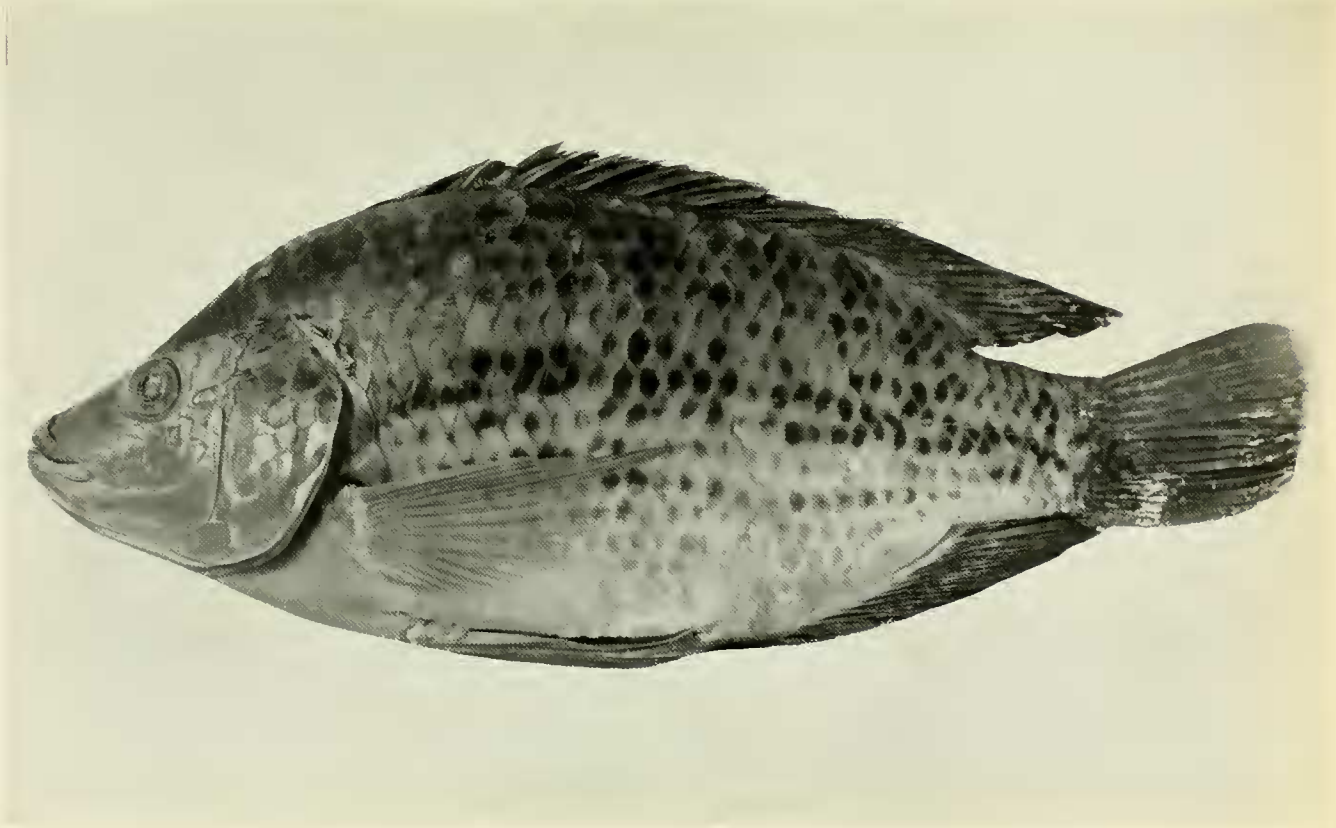
PLATE 14

Tilapia girigan, a male of 23 cm. total length from Lake Jipe.

TILAPIA GIRIGA V

PLATE 15

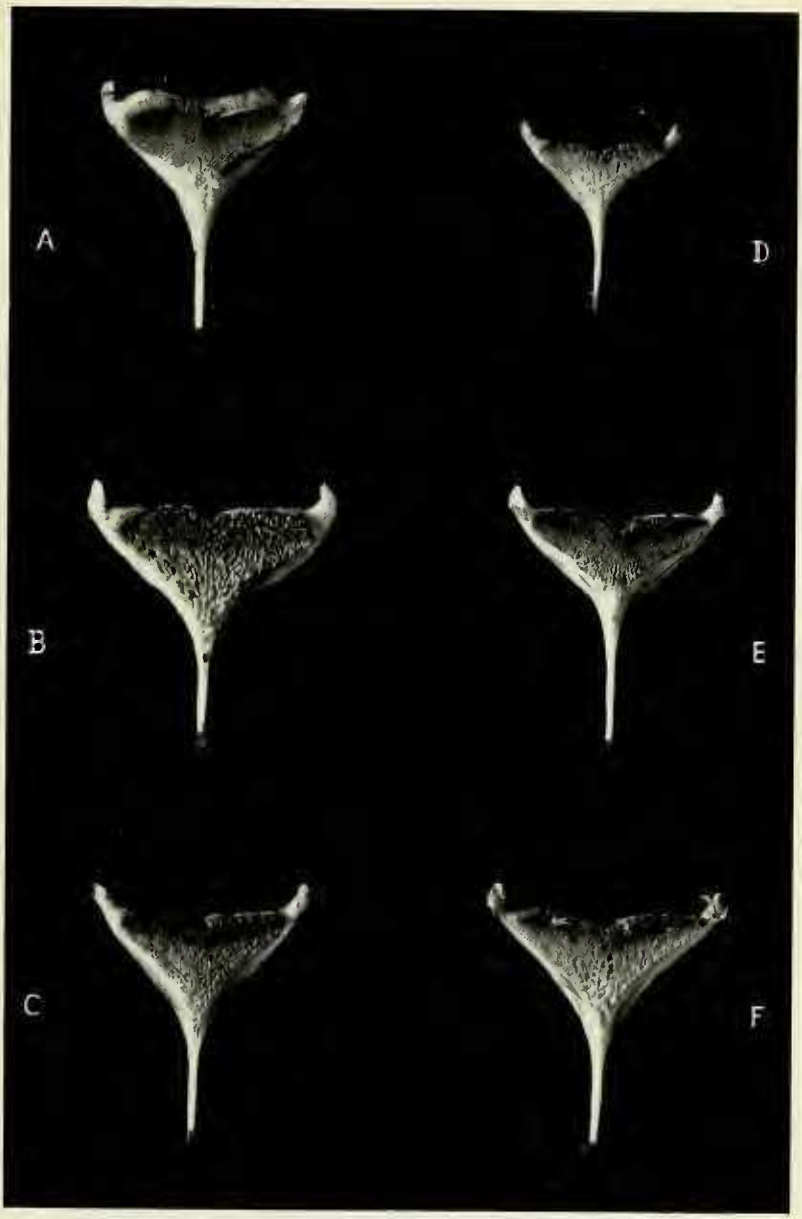
Tilapia pangani, a male of 28 cm. total length from one of the Korogwe fishponds.



TILAPIA PANGANI

PLATE 16

Lower pharyngeal bones of *Tilapia* species. A. *T. jipe* (fish 23 cm. total length). B. *T. girigan* (fish 23 cm.). C. *T. pangani* (fish 23 cm.). D. *T. mossambica korogwe* (fish 20 cm.). E. *T. mossambica* (fish 20 cm.). F. *T. nilotica* (fish 22 cm.)



TILAPIA

PLATE 17

A. Nest of Lake Jipe *Tilapia* in one of the Korogwe ponds. The whole excavation is $2\frac{1}{4}$ft. across (the ruler is 15 in. long).

B. Nests of *Tilapia esculenta* from Lake Victoria in one of the Korogwe ponds. Each excavation is about 12 in. across.

TILAPIA

TILAPIA ESCULENTA